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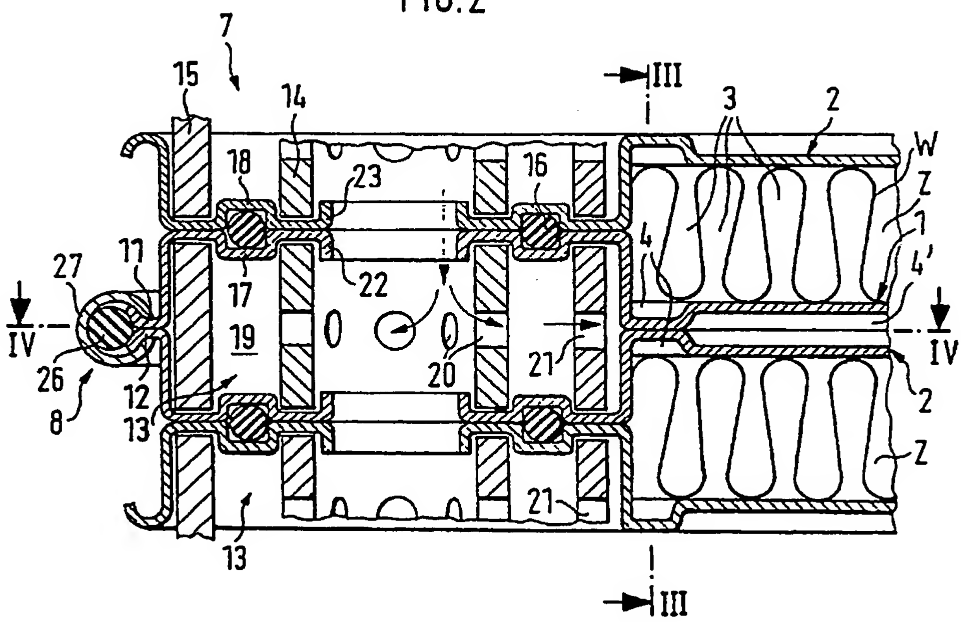
# (54) Plate type heat exchanger

(57) A heat exchanger is provided with a matrix of plates 1, 2 arranged in a stack to form separate ducts 3, 4 for two heat exchanging fluids. At least one distribution pipe 7 is formed, which is connected to the inflow or outflow ends of the first ducts 4 and is sealed relative to the second ducts 3. The plates are connected to one another in pairs in a sealing-tight manner at their outer edge region and have matching, shaped sections enclosing chambers 13 connected to the first ducts 4. In each chamber two concentric spacing rings 14, 15 form a double column taking the clamping force of the stack and along with openings in the shaped sections form the distribution pipe 7. The spacing rings comprise radial apertures 20, 21 communicating with the first ducts and form an annular chamber 19 within each chamber 13. Elastically deformable sealing rings 16 may be aligned at both axial ends of the annular chamber 19 for sealing the distribution pipe relative to the second ducts 3.

FIG. 2

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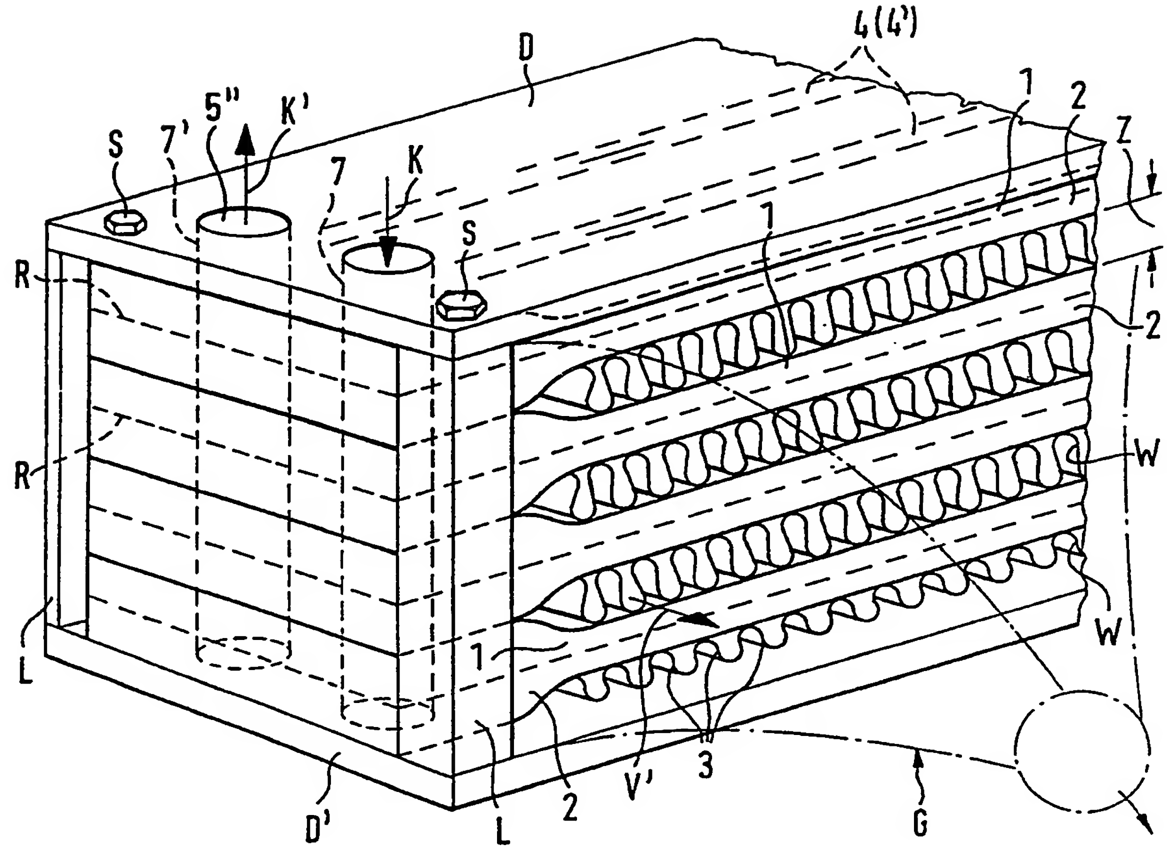



FIG.1

FIG.2

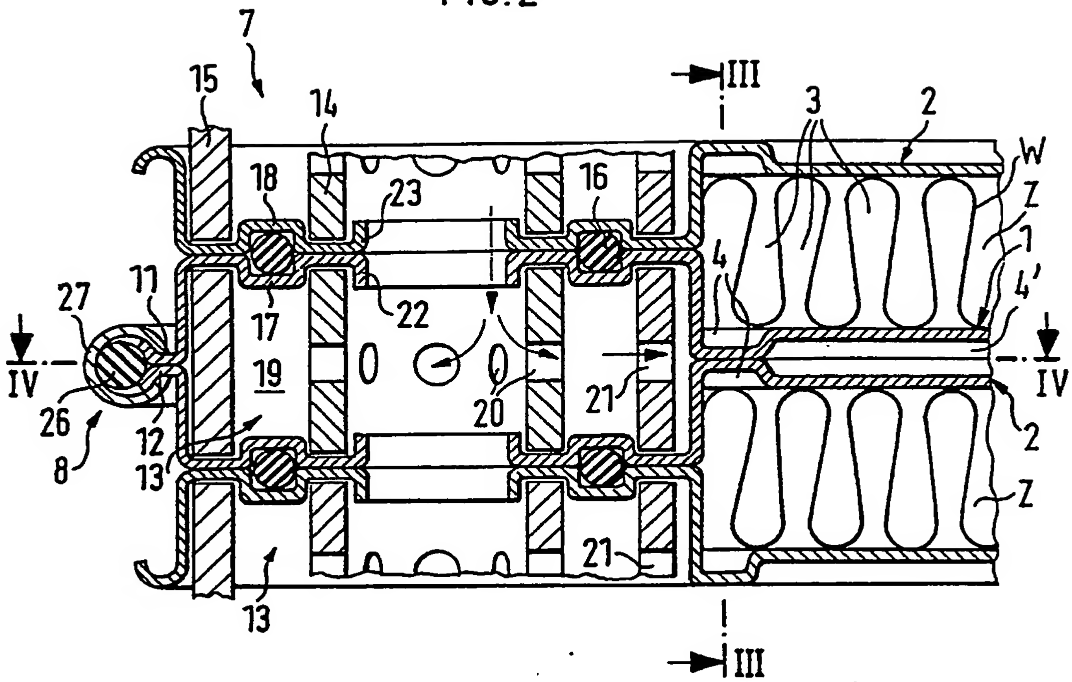

7
15
14
18
23
16
III
3
2
W
Z
1
4
4'
27
11
17
22
19
IV
20
21
26
12
8
13
21
13
III
Z
2

FIG.3

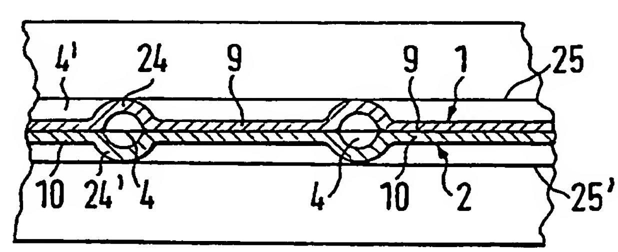
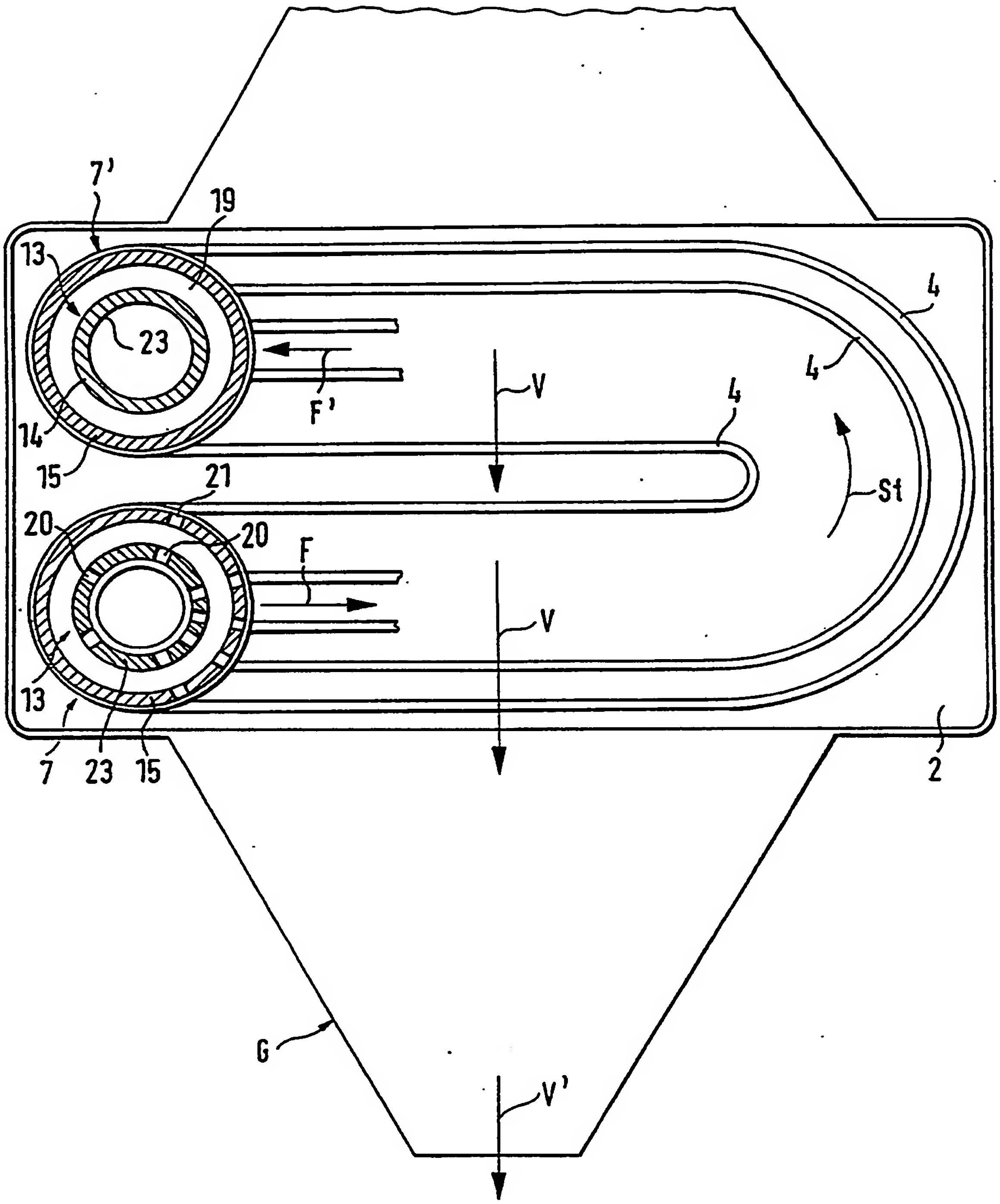

4'
24
9
9
1
25
10
24'
4
4
10
2
25'

FIG.4



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HEAT EXCHANGER

The invention relates to a heat exchanger, particularly a charging air cooler of an internal combustion engine, made of a stack of plates defining two sets of ducts for the heat exchange fluids. In a heat exchanger of this type, such as is known from US-PS 4 592 414, inflow and/or outflow or distribution pipes are to be formed adjacent one another in pairs at both ends of the superimposed plates, to be connected to one of the sets of ducts. In this respect, the plate spacing - in the longitudinal direction of the inflow or outflow pipes which are to be formed - is effected by means of plate sections which are shaped locally so that convexities are produced for each joined matching plate pair, which convexities communicate for the flow of fluid via complementary pipe openings when the plate pairs are stacked; local pipe connections can be prepared by the alternate engagement of flanges in associated pipe openings; for the respective local separation into an inflow and outflow pipe, convexities of a plate pair which can be completely separated from one another can be prepared by plate sections embossed in the shape of noses.

In the known case, each plate pair encloses one or two ducts (single- or double-pass flow) for the heat-absorbing fluid, the said ducts merging at their ends into the convexities of an inflow and an outflow pipe respectively. The plates of the pair are supported against one another and bordered along common outer edge regions in a flange or strip-like manner.

The known case requires complex and cost-intensive forming and embossing measures for the plates, and the plates have to have relatively large wall thicknesses in order to obtain a mechanically stable, self-supporting structure. The large plate wall thicknesses

have, amongst other things, the following disadvantages: no optimum heat exchange (reduced heat transfer over time); relatively large material outlay; relatively high weight. Since in the known case all the plates are to be welded or soldered together, a "modular exchange" or a "modular" extension of the heat exchanger independent of the supplier or heat exchanger manufacturer in order to adapt the heat exchanger to variable capacity and operating cycles of internal combustion engines is practically impossible; a "module" in this respect refers to a plate pair.

Nor does the known case involve any locally implemented sealing measures in order optimally to seal sections of an inflow or outflow pipe, through which a heat-absorbing fluid flows, relative to duct sections of the matrix through which heat-emitting fluid flows, or relative to the external environment. The above-mentioned sealing requirements can only be slightly improved by producing extremely precise and cost-intensive matching embossed contours (flange engagement in openings).

Furthermore, the complete plate welding of the known heat exchanger leads to a plate unit which is relatively inherently rigid, so that mechanical stresses, for example resulting from sudden loading of the vehicle, thermal loading or alternate thermal loading and local, thermally induced differences in material expansion, are inadequately compensated for (danger of material or welding seam tears and danger of plate settling with resulting leakage).

It is the object of the invention to provide a heat exchanger which has comparatively low manufacturing and material outlay (low embossing outlay/thin plates) and is relatively light in weight, allowing for an extremely simple production of inflow and outflow distribution pipes, which are optimally

sealed to withstand any likely thermal and mechanical loading.

According to the invention there is provided a heat exchanger with a matrix of plates which are arranged one on top of the other in the manner of a stack and form first and second sets of ducts separated from one another for two fluids participating in the heat exchange, and at least one distribution pipe which is connected at the inflow or outflow end to the first ducts and is sealed relative to the second ducts, in which the plates include complementary shaped sections forming chambers between them, which chambers are connected to the first ducts and in each of which two spacing rings are arranged between bearing surfaces on the shaped sections so as to form the distribution pipe, with corresponding openings in the shaped sections, and both spacing rings have apertures for communication with the first ducts and together define an annular cavity within each chamber.

The two spacing rings, which are arranged spaced apart in the chamber or annular chamber of a plate pair in each case, provide a strong, stable plate structure, wherein the plates are supported against one another and have a relatively small wall thickness. In this case, a comparatively large and circumferentially broad surface support is possible between the matching bearing or support surfaces extending over the chambers in the longitudinal direction of the pipes.

In connection with the use and arrangement of elastically deformable sealing means, preferably a respective sealing ring, e.g. made of rubber, in combination with pipe-axial plate clamping, it is possible to compensate for thermally and/or mechanically induced plate settling in a way that continues to ensure sealing, without having to take into account large clamping force losses.

Consequently, an "elastically tensioned" seal is provided in accordance with the invention, a purely metallic spacing being ensured via the rings at the respective corresponding bearing or support surfaces of the plate sections with a constantly maintained clamping force.

The design and arrangement of the annular space or cavity in the respective chamber, relative to the complementary surrounding arrangement by the plate of the elastically deformable sealing means or ring, between both axial ends of the ring in each case, allows for optimum seal cooling; this is particularly advantageous in view of the distribution pipe design on the inflow side as regards the relatively marked temperature differences between the heat-absorbing cooling fluid (cooling water) and the heat-emitting fluid (hot charging air).

A uniform, demand-regulated distribution of the heat- absorbing fluid, e.g. (inflow side) from the inner ring into the annular chamber and from there to the first ducts of the matrix, is possible as a result of the apertures or openings in the two spacing rings.

With a view to a reduced manufacturing and structural outlay, it is also advantageous that the chamber and the first ducts of the matrix connected to this chamber can be simultaneously formed by each joined plate pair.

The individual plate pairs can be structural units which are welded or soldered to one another at their outer edges and can be replaced or supplemented according to need. Alternatively, the plate pairs can be connected at their outer edges in a releasable but sealing-tight manner, so that a replacement or addition of structural units which can be assembled from individual plates can be effected relatively simply and quickly.

For a better understanding of the invention embodiments will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a perspective and schematic view of a heat exchanger in accordance with the invention;

Fig. 2 is a longitudinal section through one half of the plate matrix of the heat exchanger;

Fig. 3 is a partial section taken along line III-III in Fig. 2, and

Fig. 4 is a section along line IV-IV in Fig. 2.

Fig. 1 shows a heat exchanger as a plate charging air cooler with a clamping of the plates between outer sealing lids and an outflow-side housing contour for the cooled fluid (compressed air) flowing out of the matrix. The plates 1, 2 of the heat exchanger are arranged one on top of the other in the manner of a stack and are clamped relative to one another, preferably along the front and rear end regions, between the upper and lower sealing lids D, D', with the interposition of support strips L. The clamping can be effected by means of screw bolts, whose associated screw heads are designated by the reference S. Openings 5', 5'' in the upper sealing lid D are associated with the distribution pipes 7, 7' formed between the plates 1, 2. Heat-absorbing fluid, e.g. cooling water, is supplied via the opening 5' in the direction of the arrow K and flows through the distribution pipe 7 into a first set of ducts 4, which are enclosed between, and indeed are formed by, each pair of plates 1, 2. At the outflow end, the first ducts 4 are connected to the second distribution pipe 7', out of which the cooling water which has been heated by the supplied heat-emitting fluid, more particularly compressor or charging air V (cf. Fig. 4), exits in the direction of the arrow K' via the opening 5''. As indicated by the external outlines R in Fig.

1, the plate pairs 1, 2 can be welded together in a sealing-tight manner at complementary flange-like support sections 11, 12 (cf. Fig. 2); spot or roller seam welding can preferably be used, although a heat-resistant hard solder or a releasable clamp-seal 8 - as shown in Fig. 2 - can also be used.

The plates 1, 2 can be made, for example, of steel, copper or aluminium sheet. When assembled, they form a second duct means comprising intermediate spaces Z, in which second ducts 3 are formed by means of corrugated sheet metal inserts W, which second ducts 3 extend transversely to the first ducts 4, 4' (Figs. 2 and 3) and in which the heat-releasing fluid, more particularly hot charging air V, is guided, which fluid flows out of the matrix in the direction of the arrow V' (cf also Fig. 4) with a greatly reduced temperature in order to be supplied as charging air via an opening in the housing G to the associated internal combustion engine.

Fig. 2 shows the stacked arrangement of the plates 1, 2, illustrating the first and second ducts and a distribution pipe 7 formed by two spacing rings 14, 15 enclosed within a chamber defined by the plate pair. According to Figs. 2 and 3, the stacked pairs of plates 1, 2 form chambers 13 as they diverge from complementary adjacent support or abutment sections 9, 10 (Fig. 3) or 11, 12. In each of these chambers two coaxial metallic spacing rings 14, 15 are arranged, one outside the other. In the stacked plate pairs the inner and outer rings line up to form a column or tower of rings, one after the other in the direction of the pipe axis. An annular cavity 19 is defined between the inner and outer rings.

The chambers 13 are formed between approximately cup-shaped sections of the respective plate pairs 1, 2, one half of each chamber being formed by each spaced

plate section, the plate section being more or less mirror-symmetrical. At plate sections of the chambers 13 extending transversely to the pipe axis of the inflow distribution pipe 7, an elastic sealing of the distribution pipe 7 relative to the external environment (here: left side of the plate matrix) and relative to the second ducts 3 is effected. This sealing is effected in this example by means of a rubber ring 16, between complementary, approximately annular bearing surfaces of the above-mentioned plate sections. To assist in this, the rubber ring 16 is enclosed by complementary annular sections or grooves 17, 18 of the said plate sections, each annular groove being formed by a depression in the annular surface of the plate and enclosing approximately half of the rubber ring 16. The annular cavity 19 enclosed by the two spacing rings 14, 15 in the chamber 13 ends at the height of the said annular depressions 17, 18 in each case.

Both spacing rings 14, 15 have apertures 20, 21 extending in a common transverse plane. As shown in Fig. 2, the above-mentioned plate sections containing the annular sections 17, 18 and the sealing ring 16 engage against the radially inner side of the respective inner spacing ring 14 by means of axial flanges 22, 23, which are superimposed and angled away from one another in opposite directions. The pipe duct of the distribution pipe 7, through which the cooling fluid flows axially, is thus formed by the inner spacing rings 14 and the centrally arranged pipe connections produced by the axial flanges 22, 23. Cooling fluid supplied in the direction of the arrow K (Fig. 1) can thus be distributed in the direction of the illustrated arrows via the apertures 20 in the inner ring 14 to the annular chamber 19 and from here can be supplied via the apertures 21 in the outer ring

15 from the respective chamber 13 to the first ducts 4, 4'.

As also shown in Fig. 2, the plate sections extending transversely to the pipe axis form annular recesses with axial annular bearing surfaces between the complementary-shaped annular sections 17, 18 and the axial flanges 22, 23 on the one hand and the pipe-axial circumferential wall sections of a chamber 13 on the other hand in order to provide a centring support for the spacing rings 14, 15 in the transverse plane.

The respective "first ducts" are formed on the one hand by cylindrical distribution ducts 4 of short axial extent, respective halves of which are formed by complementary profile sections 24, 24' (Fig. 3) shaped from the complementary support sections 9, 10 and on the other by circumferential wall sections of the cup-shaped chamber 13, parallel to the pipe axis. The distribution ducts 4 open into further duct structures 4', which are rather wider and in this case are formed on the side of the support sections 9, 10 remote from the chamber 13, between shell-like widened or diverging sections 25, 25' of a plate pair 1, 2, i.e. plate sections deformed away from the mirror-image plane.

It is possible to provide a releasable, sealing clamping connection 8 along the support sections 11, 12 meeting tangentially at the outer edge. Tongue-like, outwardly rounded, enlarged end sections of the support sections 11, 12 each enclose approximately half of a sealing cord 26, for instance made of rubber, a tubular clamping strip 27 compressing the support sections 11, 12 in the manner of pliers, thereby enclosing the sealing cord 26 and the tongue-like end sections so as to clamp the various parts together.

Fig. 4 is a section taken along line IV-IV in Fig. 2 showing complementary first ducts formed between one plate pair and guided with reverse flow for a cross-

counter flow heat exchanger, the first ducts being connected at the inflow or outflow side to chambers with the respective two rings. This represents an alternative application of the invention for a plate heat exchanger, more particularly a charging air cooler, with a cross-counterflow construction. In this case, a U-shaped pipe panel with the first ducts 4 is enclosed between the plate pairs 1, 2 and projects transversely to the pipe axis of the inflow and outflow distribution pipes 7, 7'. The cooling fluid flows, with a reversal of the direction of flow (arrow St), through the pipe panel comprising the first ducts 4 in opposite directions in the straight-limbed regions, the pipe panel being connected at the inflow end (arrow F) to the first distribution pipe 7 and at the outflow end (arrow F') to the second distribution pipe 7' via the respective chambers 13. In order to form the intermediate spaces Z for the second ducts 3 (Figs. 1 and 2), the plates 1, 2 in Fig. 4 can be supported against one another at the right-hand end by block-like plate protrusions. Heat-emitting fluid, e.g. hot charging air or compressor air, flows through the ducts 3 substantially transversely to the respective panel of ducts 4, in the direction of the arrow V. The charging air, whose temperature has been reduced by heat exchange, can thus exit in the direction of the arrow V' via an outflow section of the housing G and a housing opening and can be supplied to the internal combustion engine.

The invention can also be used, for example, in a plate heat exchanger having a triple-cross-counterflow construction, with a substantially diametrally opposed arrangement of the inflow and outflow distribution pipes 7, 7' formed between and via the plates 1, 2. In this case, a duct matrix is provided which can be divided into three duct panel sections, through which

the cooling water flows in opposite directions, the duct matrix being connected at the inflow side via respective rings to the inflow distribution pipe 7 and at the outflow side via respective rings to the outflow distribution pipe 7'. In contrast to the arrangement according to Figs 1 to 4, the inlet into the inflow distribution pipe 7 can be arranged at the top and the outlet of the outflow distribution pipe 7' can be arranged at the bottom.

The invention can also be used, for example, in a plate heat exchanger in which inflow and/or outflow distribution pipes, which are arranged parallel to one another and spaced apart, can be formed preferably in both end sections of the plate matrix. In this case, the cooling water can flow in opposite directions through ducts 4, which are separated from one another locally, in respective pipe panels between plate pairs, the ducts being connected at the inflow side to an inflow distribution pipe and at the outflow side to a outflow distribution pipe in each case.

It will be clear that the invention is concerned with the construction of a heat exchanger element comprising a plate pair and inner and outer rings within the plate pair to provide at the same time support for clamping such plate pairs together and a distribution pipe for one cooling fluid. This duct means 3, 4 in the plane of the plates can take any suitable form.

**CLAIMS:**

1. A heat exchanger with a matrix of plates (1, 2) which are arranged one on top of the other in the manner of a stack and form first and second sets of ducts (3, 4, 4') separated from one another for two fluids participating in the heat exchange, and at least one distribution pipe (7), which is connected at the inflow or outflow end to the first ducts (4, 4') and is sealed relative to the second ducts (3), in which the plates (1, 2) include complementary shaped sections forming chambers (13) between them, which chambers are connected to the first ducts (4, 4') and in each of which two spacing rings (14, 15) are arranged between bearing surfaces on the shaped sections so as to form the distribution pipe (7), with corresponding openings in the shaped sections, and both spacing rings (14, 15) have apertures (20, 21) for communication with the first ducts and together define an annular cavity (19) within each chamber (13).

2. A heat exchanger according to claim 1, in which the annular cavity (19) axially adjoins elastically deformable sealing means (16) at both ends, which seal the distribution pipe (7) relative to the second ducts (3) by way of plate clamping in the direction of the pipe axis via the bearing surfaces and corresponding surfaces located outside the chambers (13).

3. A heat exchanger according to claim 2, in which the respective sealing means (16) comprises at least one sealing ring made of rubber half-enclosed in each case by matching shaped annular portions (17, 18) formed in superimposed transversely extending plate sections of the chambers (13).

4. A heat exchanger according to claim 3, in which the plate sections of the chambers (13) have annular recesses on either side of the sealing ring

(16), into which the axial ends of the spacer rings (14, 15) engage.

5. A heat exchanger according to any preceding claim, in which the complementary plate sections forming the chambers (13) have generally corresponding openings surrounded by axial tubular flanges (22, 23) angled away from one another in opposite directions so as to engage through the inner spacing rings (14).

6. A heat exchanger according to claim 5, in which the formed plate sections extending transversely to the pipe axis and mutually supported at opposing annular bearing surfaces form annular recesses with axially facing annular bearing surfaces between the matching shaped annular sections (17, 18) and the axial flanges (22, 23) on the one hand and on the other hand circumferential wall sections of one chamber (13) extending in the direction of the pipe axis, for providing centring support for the spacing rings (14, 15) within the chambers (13).

7. A heat exchanger according to any preceding claim, in which the plates (1, 2) are connected to one another in pairs in a sealing-tight manner at their outer edge region, namely at complementary abutting support sections (11, 12), in planes extending transversely to the pipe axis in each case, and between matching shaped profile and plate sections (24, 24'; 25, 25') enclose the first ducts (4, 4'); and at the inflow or outflow side of these ducts the plates (1, 2) widen out into the chamber (13) in each case approximately halfway up the axial chamber wall.

8. A heat exchanger according to any preceding claim, in which the second ducts (3) are arranged transversely to the first ducts (4, 4') in intermediate spaces (Z), which are formed in the plate stack between the sections of the plates (1, 2) which in pairs form and enclose the first ducts (4, 4').

9. A heat exchanger according to any preceding claim, in which the complementary shaped sections are shaped with matching cup or bowl profiles extending from matching abutting surfaces to form the chambers (13).

10. A heat exchanger according to any preceding claim, in which the apertures (20, 21) or openings in the spacing rings (14, 15) are arranged approximately at the height of the first ducts (4, 4') of the matrix.

11. A heat exchanger according to any preceding claim, in which the plate pairs (1, 2) enclosing the chambers (13) and spacing rings (14, 15) are soldered or welded at their edges, or are releasably connected to one another at their edges by a sealing clamping connection (8).

12. A heat exchanger according to any preceding claim, in which the respective outer spacing ring (15) in the chamber (13) is arranged at least over part of its circumference with a transverse spacing from the opposite chamber wall via which the first ducts (4) are connected to the chamber (13) for the flow of fluid.

13. A heat exchanger substantially according to any of the embodiments described herein with reference to accompanying drawings.

14. A heat exchanger element comprising a pair of shaped plates facing each other and forming or containing a duct means between them for the passage of one heat exchange fluid via a distribution pipe extending perpendicularly to the plates, wherein the plates further form between them at least one chamber and the element further includes an inner and an outer support ring each extending over the perpendicular height of the chamber, the inner ring defining a portion of the distribution pipe and being in communication with the duct means.

**Patents Act 1977**
**Examiner's report to the Comptroller under Section 17**
**(T. Search report)** 14.

**Application number**
9404658.8

**Search Examiner**
T M JAMES

**Date of completion of Search**
9 MAY 1994

**Documents considered relevant following a search in respect of Claims :-**
1-14

**Relevant Technical Fields**

(i) UK Cl (Ed.M) F4S (S4G, S4JY, S4JX)

(ii) Int Cl (Ed.K) F28F (3/00, 3/08, 3/10, 7/00, 7/02, 9/02)

**Databases (see below)**
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| Category | Identity of document and relevant passages | | Relevant to claim(s) |
|---|---|---|---|
| A | GB 0573998 | (AUSTIN & WOOD) See Figure 4 | |
| A | EP 0021161 A1 | (HOECHST AKTIENGSELLSCHAFT) See Figures 1 and 3 | |
| A | EP 0008268 | (CEA) See Figure 2 | |

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